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Replacement migration, or why everyone is going to have to live in Korea: a fable for our times from the United Nations

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This paper considers international migration in the context of population ageing. In many Western countries, the search for appropriate responses to manage future population ageing and population decline has directed attention to international migration. It seems reasonable to believe that international migrants, mostly of young working age, can supply population deficits created by low birth rates, protect European society and economy from the economic costs of elderly dependency, and provide a workforce to care for the elderly. Particular prominence has been given to this option through the publicity attendant on a report from the UN Population Division in 2000 on 'replacement migration', which has been widely reported and widely misunderstood. Although immigration can prevent population decline, it is already well known that it can only prevent population ageing at unprecedented, unsustainable and increasing levels of inflow, which would generate rapid population growth and eventually displace the original population from its majority position. This paper reviews these arguments in the context of the causes and inevitability of population ageing, with examples mostly based on UK data. It discusses various options available in response to population ageing through workforce, productivity, pensions reform and other means. It concludes that there can be no 'solution' to population ageing, which is to a considerable degree unavoidable. However, if the demographic regime of the United Kingdom continues to be relatively benign, future population ageing can be managed with tolerable inconvenience without recourse to increased immigration for 'demographic' purposes. At present (2001), net immigration to the United Kingdom is already running at record levels and is now the main engine behind UK population and household growth. By itself, population stabilization, or even mild reduction, is probably to be welcomed in the United Kingdom, although the issue has attracted little attention since the 1970s.

Keywords: migration; low fertility; age structure; population ageing

1. POPULATION AGEING

(a) *The problem of population ageing*

Population ageing is one of the most important social and demographic transformations ever to face human societies. It can be defined as a substantial and permanent increase in the numbers of older people (conventionally those aged 65 and older) relative to the rest of the population, with a corresponding increase in the mean age of the population. This might arise from an absolute increase in the numbers of the elderly, an absolute decline in the numbers of the younger population (conventionally those aged under 15) or both, as at present in the majority of developed countries. In 1900, *ca.* 5% or less of the populations of the West were aged 65 and over, a proportion relatively unchanged for centuries. By the year 2000, the proportion of Europe's population aged 65 and over had trebled to 15%. If birth and death rates were to remain as they are in 2001, and ignoring migration, Western populations would eventually acquire stable population structures with between 22 and 35% of their populations aged 65 and over (table 1). Given these trends, older populations will also be declining in absolute number. Even with some increase in fertility, population decline is expected to become apparent in almost all industrial countries at various times in the next 40 years.

Problems arise from the transformation of age structure because it implies a reduction in the ratio of economic production to consumption. In specific demographic terms, the ratio of older persons normally assumed to be dependent (conventionally aged over 65) increases adversely in comparison with the numbers assumed to be active economically and in other ways (conventionally 15–64), on whom the older members of the population are held to depend. Expected increases in this 'burden of dependency' are highlighted statistically by the dependency ratio; that is, the ratio of dependants to every 100 people in the active population. Children aged under 15 are also conventionally defined as 'dependants' in comparative demographic analysis (although of course dependency now extends much later in life). Children are the main focus of dependency in the youthful and rapidly growing populations of much of the less developed world. Here, however, we are concerned only with the aged dependency ratio (ADR); the ratio of the number of people aged 65 and over to every 100 people aged 15–64, that is $\text{ADR} = (\text{pop } 65+/\text{pop } 15\text{–}64) \times 100$. These age limits are somewhat arbitrary and increasingly unrealistic under today's conditions, but serve at least to allow demographic

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Table 1. Stable age distributions at given levels of mortality and fertility.
(Expectation of life at birth in all cases is 80.0 years for females, 76.0 years for males. TFR, total fertility rate—the average family size implied by current fertility rates. Source: calculated from Coale & Demeny (1983), pp. 79 and 129.)

	TFR 1.55	TFR 1.78	TFR 2.07
rate of population change (per 1000)	−10.0	−5.0	0.0
mean age	46.8	43.9	40.9
percentage population under 15 years	13.0	15.7	18.7
percentage population aged 15–64	59.4	60.7	61.3
percentage population aged 65+	27.6	23.7	20.1
overall dependency ratio	68.3	64.9	63.2
aged dependency ratio	46.5	39.0	32.7
potential support ratio	2.2	2.6	3.1

comparison of the potential burdens that are generated by the different age structures of various populations over time and space. Recent trends in health, survival and above all in attitudes and expectations that relate to older people are transforming our understanding of the boundaries of 'old age' (Laslett 1991, 1996), as we will see later in the paper.

Very often, the reciprocal of the ADR is used, the potential support ratio (PSR). That is, the ratio of the number of people in the nominally active population aged 15–64 to every nominal dependant aged 65 and over: PSR = (pop 15–64)/(pop 65+). Values for both are given in table 1.

It must be remembered that both of these age-group categories are demographic abstractions and might be a long way from the ratio of the number of actual dependants to those who are economically active. Population ageing brings in its wake a substantial decline in this PSR, from about 10 in 1900 and all previous times, to about four in most developed countries today, falling to between two and three by the mid-21st century, depending mostly on the future trend of the birth rate. Without further major changes in birth or death rates, a narrow range of PSR between two and three would then become typical of the human species, as fewer children and longer lives become universal.

(b) *The problem of population decline*

For two centuries, the Western world has taken some level of population growth for granted. In most countries, that is coming to an end. The recent UN report on replacement migration (2000*a*) seems to assume that population decline is *ipso facto* undesirable. These ideas reflect transatlantic rather than universal Western concerns; population stabilization or reduction might be contrary to the American dream but regarded with equanimity elsewhere. It is true that 'Malthusian' views do not find favour with most French opinion either (Chesnais 1995), but the last official report on population in the United Kingdom (Population Panel 1973) welcomed the prospect of an end to growth. Official responses in Germany (Höhn 1990) have discussed the management of population decline and the government of the Netherlands has, in the past, defined it as a policy aim in the long term. For example, the report of the Dutch Royal Commission on Population 1977 (Staatscommissie Bevolkingsvraagstuk 1977) stated that 'termination of natural population growth is desirable and possible as a consequence of below replacement fertility as expected in the official population projections. However, government should not lose sight of reaching, in due time, a more or less stationary population situation which could imply that in the longer term government should promote fertility stabilising on a level guaranteeing the replacement of successive generations'. The government response (Tweede Kamer der Staten Generaal 1983) concluded that 'Continuing population growth will have an adverse effect on the wellbeing of the nation, and therefore the perspective of growth coming to an end as a consequence of below-replacement fertility (as observed since 1972) is welcomed' (pp. 234–236). More recent official statements still maintain the view that 'in the longer run a stationary population is viewed as desirable' (Government of the Netherlands 1998, p. 9). The economic and social consequences of population stabilization are seriously under-researched, although they attracted a lot of attention in the 1930s.

(c) *The causes of population ageing*

Population ageing is a permanent, irreversible consequence of the achievement of low, average family size and longer expectation of life in developed countries. The course of the 19th- and 20th-century demographic transition from high to low levels of mortality and fertility was unique and unrepeatable in the history of the human species. It has transformed average completed family size in the developed world from five or six to about two or (usually) less, and more than doubled expectation of life from (at most) 35 to 75 years. The rest of the world is expected to have completed this transition by the end of the 21st century. Some contrasts are shown in figure 1. By 1991, Uganda had made considerable progress through the transition to lower death rates, but with hardly any reduction in family size. Accordingly, its population is growing rapidly, with a youth dependency ratio (YDR) of 103, an ADR of 7 and a PSR of 14.7 (nominally) active people per elderly person over age 64. At the other extreme, Italy has had low fertility for many years: deaths now exceed births, the elderly outnumber the young. The YDR (21.4) has been overtaken by the ADR (25.6) with a corresponding PSR for the elderly of 3.9.

Initially, declines in the birth rate were the primary engine behind population ageing. Lower birth rates reduce the size of young cohorts and therefore the burden of youth dependency. They thereby increase the relative size of older cohorts relative to the total population without directly increasing their actual number ('ageing from the bottom', or 'ageing from the base' in Pressat's terminology). In chronological terms, death rates fell below birth rates in most populations. The initial effect of

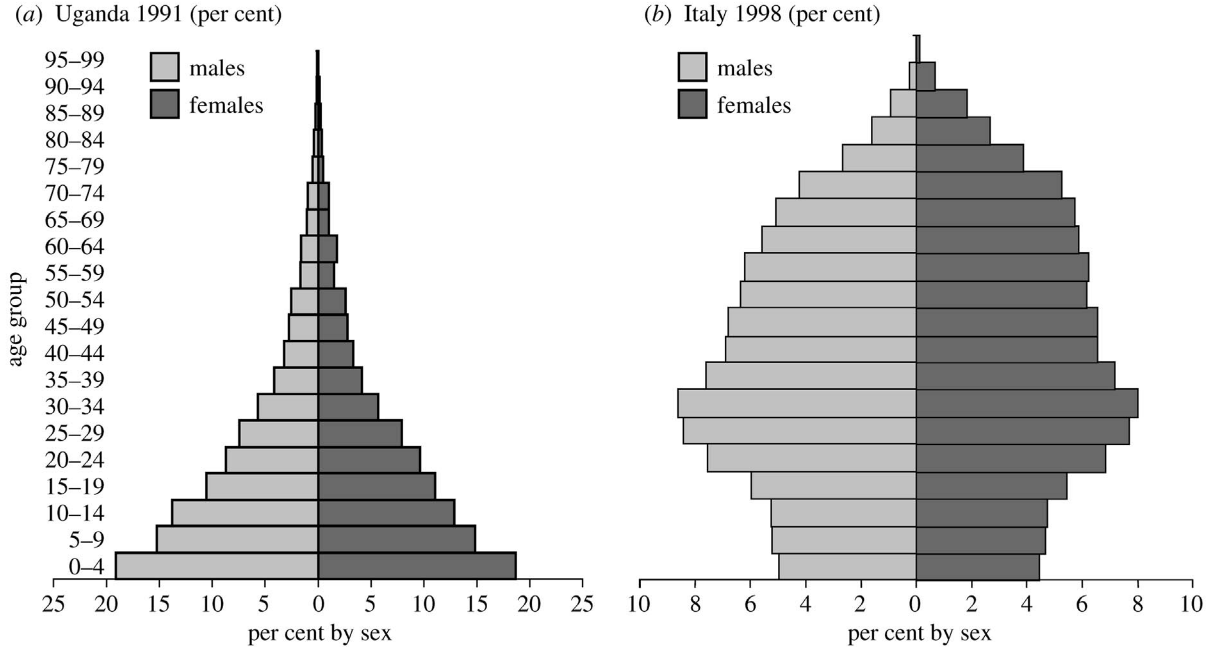

Figure 1. Contrasting population age structures in Uganda (1991) and Italy (1998). (Sources of data: Uganda, United Nations *Demographic Yearbook* (United Nations 1999); Italy, Eurostat *Demographic statistics* (Eurostat 1999).)

the fall in mortality from high levels is, however, to make the population younger, by improving the survival of infants and children, and of young mothers. Eventually, once high rates of survival have been achieved (for example, an expectation of life of about 60 years), further reductions in death rate can at last have their intuitively expected effects of making the population older.

Today in modern societies, 98% of babies can expect to live to age 50, which is above the average age of the population. In those countries, death rate improvements are now inevitably and increasingly concentrated among the late middle aged, the old and the 'oldest-old' aged over 85. Death rates continue to fall at between 1 and 2% per year, even among the very elderly—an unexpected and remarkable phenomenon (Kannisto *et al.* 1994; Vaupel 1997). All this directly increases the number of elderly 'ageing from the top' or 'ageing from the summit'.

In the West, birth rates first declined to below the 'replacement' total fertility rate (TFR) of 2.1 children on average (strictly 2.075 at current UK mortality rates) as early as the 1930s, a fact obscured by the unexpected intervention of the 'baby boom' of the 1950s and 1960s. Since the 1970s, most Western countries have returned to lower birth rates, in almost all cases below the replacement level—much as in the 1930s. It is not true, however, that the developed world has 'declining' birth rates in 2001. Birth rates, although low, are constant or even increasing slightly in some countries, partly because of the partial recuperation of fertility at older ages that has been continually postponed from younger ages since the 1970s.

Because of this relative stability, low fertility is giving way to low mortality as the primary force of population ageing. In those countries, in which birth-rate decline happened first—notably France—almost all population ageing is now due to continued falls in the death rate (Calot & Sardon 1999). This will eventually be so in all countries as long as birth rates fall no further. The extent to which declines in the death rate can continue at their present rate is hotly disputed (Olshansky & Carnes 1996). Few projections dare to incorporate expectations of life beyond age 85, although on past experience, actuaries have been too conservative in this regard (Murphy 1995*b*).

Population age structures and their associated dependency ratios respond to these changes in vital rates with a considerable time lag. This is because of the time it takes for cohorts of a given size to mature through the age structure. This phenomenon of 'demographic inertia' or 'momentum' explains why age structures are often out of line with their vital rates; for example, this is how countries with below-replacement fertility rates (all of Europe since the 1970s) can maintain an excess of births over deaths for many years (most of Europe for the next decade at least). It takes about two generations—almost 60 years—for any stable population structure to emerge that is compatible with its own vital rates and that is then self-replicating.

In the latter part of the 20th century, developed countries enjoyed an unusually favourable age structure compared with the youth burden of the earlier part of the transition and with the elderly burden to come. As a result of declining birth rates from the 1880s, the relative number of the dependent young declined. During much of the 20th century, that lightening burden was combined with a relatively small elderly population inherited from an earlier demographic regime. This transiently favourable situation, typical of the latter half of the demographic transition, is now finally being lost. The populations of the less developed world (the majority of which have begun fertility decline) will enjoy a similar phase up to the middle of the 21st century. In these processes, fertility always has a more powerful effect on age structure than mortality, because all the population changes that it generates arise at age zero. Nonetheless, mortality change will eventually become the driving force behind all further population ageing in developed countries, if birth rates have now ceased to decline.

Migration has nothing to do with any of this. In terms of its effects on age structure, migration is the weak sister of population dynamics and has been relatively ignored as a demographic process. Its unfashionable status arises partly because of the multiplicity of its numerous definitions compared with the hard biological end-points of conventional demography, the confusion of its statistics, the poverty of its theory and the unseemly passions that often surround its discussion. Technical demographic theory that is concerned with stable, and other, populations has been based mostly on closed populations, which facilitate finite solutions. This is at least partly justified in empirical terms, as at the international levels net migration is usually at least an order of magnitude less than the vital processes of fertility and mortality.

The inefficiency of its demographic effects is gauged in terms of the changes in age distribution achieved for a given change in population total. The mean age of migrant populations, although usually 10 years or more younger than the population average of modern developed countries, is not sufficiently low to influence strongly the average age, except with very high rates of flow. Furthermore, of course, for a given effect on the age structure the inflow must be continuous, as immigrants themselves age and need to be replaced. This process unleashes population growth, so that increasing absolute numbers of immigrants must arrive to maintain the same impact on the age structure.

By contrast, fertility has by far the most powerful effect on age structures of the three components of population change. As noted above, it adds (or subtracts) people only at exact age zero, at the bottom of the pyramid. The other two processes 'add' additional people at many points in the age structure, peaking at 30 in the case of net migration. Mortality reduction saves lives—adds people—mostly at older age. A change in fertility, however, will take almost 20 years to have any impact on the size of the 'active' population; until that time it will increase overall dependency levels.

(d) *No 'solution' to population ageing*

It is important to realize that there can be no 'solution' to population ageing and low PSRs without a resumption either of the high death rates and low birth rates of the pre-transitional regime, or at least of high birth rates alone. This would generate exceptional and unsustainable population growth, bringing its own nemesis. The consequences of population ageing might—given reasonable birth rates—be ameliorated or managed by non-demographic responses, but not 'solved'.

2. IMMIGRATION AS DEMOGRAPHIC SALVATION?

In 2000, the prospect of demographic salvation from population ageing by migration was awakened among the credulous by a report from the UN Population Division (United Nations 2000*a*) on replacement migration. Coming at a time of intense debate about the desirability or otherwise of the current very high levels of immigration to the Western world, this report informed the less fertile nations of the industrial world that they would have to think again about international migration. The impression given was that substantial increases in immigration, some of them astronomical, were the only option in many cases to prevent declining population, declining workforce and declining PSR. These three claims for the demographic effects of migration are separate and need to be examined in turn.

Typically, these three aims require progressively higher numbers of immigrants. In each case, there are three considerations: (i) the overall numbers needed, averaged over a period of years, (ii) the variation in those numbers to give a reasonably constant population or workforce from year to year, and (iii) the effect on population growth and composition in each case. The general answer to these questions has been known for many years, both in theory and from several empirical studies (Lesthaeghe *et al.* 1988). Earlier work (briefly reviewed in Feichtinger & Steinmann (1992) and Espenshade (1986)) was more concerned with problems of overpopulation and the effects of constant migration streams. For example, Keyfitz (1971) showed that the effects of emigration on population growth were weak compared with the effects of fertility reduction. Pollard (1973) and others showed that constant migration into a population with below-replacement fertility always leads to a stationary population (i.e. one neither growing nor declining in numbers), as long as immigrant fertility eventually converges. The final stationary population might of course be much smaller than the original one, and with below-replacement fertility the original population would eventually die out, leaving no descendants if the populations did not intermarry. Any population with sub-replacement fertility that attempts to maintain a given population size through immigration would, accordingly, acquire a population of predominantly, eventually entirely, immigrant origin. Populations can only adopt this solution to stabilize the numbers at the risk of a loss of their original identity.

(a) *Immigration and population decline*

In principle, immigration can stop any level of population decline, but the volume of migration in some cases would be very large and, on a year-to-year basis, highly variable (Lesthaeghe *et al.* 1988; Wattelar & Roumans 1990). For example, in the Russian Federation in 1999, deaths exceeded births by 930 000. In Germany, however, although 300 000 immigrants per year were computed in the 1980s as needed to maintain population size in the long term (given below-replacement fertility), immigration levels up to the late 1990s have been so high that the German population has actually grown substantially, although not necessarily to the satisfaction of the Germans (natural decline in Germany in 1998 was 67 000, composed of a net decline of 154 000 persons of German nationality and a net addition of 86 000 births to mothers of foreign nationality). In the United Kingdom, with a higher rate of fertility, maintaining the current population in the short term requires a reduction of immigration, which became the main component of population and household growth in the late 1990s. Until at least 2035, maintenance of population size merely requires the continuation of the status quo. Later developments in the United Kingdom are discussed below.

(b) *Immigration and the workforce*

In general, the volume of immigration 'required' to protect the size of the workforce from any future decline is more substantial than that required simply to keep the population constant, and also more variable over time, for age-structure reasons. A higher fraction of any ageing population of constant size consists of retired people (assuming constant working-age limits). Fluctuations of the population of working age that arise from previous changes in the birth rate are proportionately greater than the fluctuations in total population size, thus requiring higher volumes and greater variation of annual immigration levels. By 2050, the population size implied by the 'required' migration to keep the UK working-age population constant at 1998 levels is only 63 million and remains at about that level until the end of the century—a smaller total than in the official 1998 'Principal Projection' by the Government Actuary's Department (GAD) (Government Actuary 2000). This is because the United Kingdom is already experiencing a high level of migration, considerably more than it 'needs'. The United Kingdom also enjoys a relatively benign fertility regime, which ensures that projected declines in any sector of the population are small. More widely, although numerical declines in the population of active age are projected for the medium term in many countries, improvements in workforce participation might more than compensate. Europe has substantial reserves of employable manpower that potentially exceed short-term demographic deficiencies. However, their mobilization will require structural readjustments and the effects of enhanced workforce participation to age 65 cannot extend much beyond 2025 (Punch & Pearce 2000). Thus, it is claimed that general increases in labour migration over and above present levels are not needed to satisfy quantitative workforce deficiencies in much of Western Europe (special skills excepted) up to 2020, although Italy and other southern countries are exceptions (Feld 2000). In the southern countries, the demand for labour migrants coexists with very high structural levels of unemployment. However, McDonald & Kippen (2001) take a longer time-scale and come to less-favourable conclusions of population and workforce models, which they present for 16 industrial countries up to 2050. Italian experts, for example, insist that further immigration for workforce purposes is unavoidable in view of their very low birth rate (Golini 2000), despite continued high levels of unemployment.

(c) *Immigration and the potential support ratio*

Preventing the ageing of populations with migrant inflows, in terms of preserving the current ADR or PSR, is even more difficult, except with extreme levels of immigration that would provoke very high and implausible levels of population growth. Immigration certainly tends to reduce average age and to improve the PSR, as will be shown below using the United Kingdom as an example. However, because immigrants are not very much younger than the populations they are moving into—about 10 years or so on average—the gearing required to change the average age is unfavourable. Immigration has a low 'demographic advantage', to borrow a term from engineering. Large numbers are required for modest results. Then immigrants themselves age and need to be replaced by further immigrants. Immigrants to the West also tend to have higher birth rates than the natives, but these birth rates tend to converge.

The variety of empirical studies made on the age-structure effects of immigration are difficult to compare because their starting assumptions are different. But they all lead to similar conclusions (see, for example, Kuijsten 1995). For example, it was shown nearly 20 years ago that to preserve a PSR of 3:1 in Belgium (slightly less than the 3.5:1 today) by 2020, replacement fertility would be needed, as well as some sharper peaks of migration—up to 180 000 per year, 10 times the then current gross flow (Calot 1983). That policy would itself double the population. To keep the proportion of the Dutch population (which has a 'favourable' projected age structure) over age 65 at the present level of 14%, an additional five million immigrants would be needed up to 2032 given low fertility, and three million given higher fertility, above 1990 levels (Van Imhoff & Keilman 1996). The level of replacement migration in the UN study required to maintain the support ratio would generate unimaginably high immigration. In the United Kingdom, the average annual inflow of 1.2 million immigrants 'required' for this purpose would double the population in 50 years, and then more than double it again by the end of the century (Shaw 2001) and so on *ad infinitum*. Thus, the UK population would exceed 100 million even by 2030, 200 million by 2070 and 300 million by 2090.

The difficulty of correcting ageing through immigration, except through very high population growth, has also been underlined by a comparative analysis from the European Commission (1996, 1998). Although it would 'only' take between 500 000 and one million additional immigrants per year to avert population decline in the European Union in the earlier part of the next century, to preserve the current age structure of the 15 EU countries would require 4.5 million (net) immigrants per year by 2007 and seven million net per year by 2024. This would generate substantial population growth. In the extreme case, preserving the current PSR in Korea would require the entire current population of the world to go to live there by 2050 (United Nations 2000*a*, p. 56). The sensational results from this adventurous projection have been widely interpreted as policy requirements, not speculations from a hypothetical exercise (see United Nations 2000*b*), despite the cautions expressed in the report.

(d) *Ethnic replacement*

The results of these hypothetical calculations have implied that very high proportions of the populations concerned—eventually a majority—would be of immigrant origin. The UN report made some simple calculations to that effect, assuming for the sake of simplicity that immigrant fertility immediately declined to that of the host population and that no previous immigrant-origin population existed. Neither of these assumptions is correct, but the UN data provide a baseline. Fertility levels of immigrant populations are usually higher than those of Western host populations. It is generally expected that the fertility of immigrant populations will eventually converge with those of the host population (Coleman 1994), although so far only a few populations of less-developed-world origin have completed this process. Indeed, in the case of Bangladeshis in the United Kingdom, the period fertility rate reported in the mid-1990s seems to be higher than that in Bangladesh itself.

In the long term, the minority will become the majority in a country if there remains even one region in which the

Table 2. UN 'replacement migration' population projections for the United Kingdom, 1995–2050.
(Source: United Nations (2000*a*), pp. 67–68, table A14, pp. 130–131.)

	1995	2050
(i) zero migration		
population (millions)	58.3	55.6
percentage aged 65+	15.9	25.0
potential support ratio	4.1	2.4
cumulative immigration 1995–2050 (millions)	—	0.0
mean annual immigration (thousands)	0.0	0.0
percentage population from post-1995 immigration	—	0.0
(ii) constant total population target		
population (millions)	58.3	58.8
percentage aged 65+	15.9	23.9
potential support ratio	4.1	2.5
cumulative immigration 1995–2050 (millions)	—	2.6
mean annual immigration (thousands)	0.0	47.9
percentage population from post-1995 immigration	—	5.5
(iii) constant age group 15–64 (constant working-age population)		
population (millions)	58.3	64.4
percentage aged 65+	15.9	22.9
potential support ratio	4.1	2.6
cumulative immigration 1995–2050 (millions)	—	6.2
mean annual immigration (thousands)	—	113.6
percentage population from post-1995 immigration	—	13.6
(iv) constant potential support ratio		
population (millions)	58.3	136.1
percentage aged 65+	15.9	15.9
potential support ratio	4.1	4.1
cumulative immigration 1995–2050 (millions)	—	59.8
mean annual immigration (thousands)	—	1086.8
percentage population from post-1995 immigration	—	59.0

proportion of the minority continues to increase through immigration and/or higher birth rates (Steinmann & Jäger 1997). Only a few long-term population projections have explored these prospects. In the United States, for example, the displacement of the white non-Hispanic population from its majority position is officially projected to occur around 2050 (US Bureau of the Census 1993). No European population projection is so decisive. The trends, though all pointing in the same direction, are mostly slower paced than in the United States. For example, the total population in the Netherlands is projected to flatten out at approximately 18 million people from about 2030 onwards. In that 18 million, the population of foreign origin (defined as immigrants and their children) will have risen to six million (33% of the total) by 2050 and will still be increasing. That six million is projected to comprise four million people of non-European origin and two million Europeans (each population in 2000 numbered about 1.4 million). By 2050, the European-origin foreign population will have ceased to grow, whereas that of non-European origin is projected to be growing rapidly thanks to the momentum inherent in its age structure, even though fertility is by then assumed to have fallen to replacement level or less (Alders 2001; Alders & Schapendonk-Maas 2001).

In Germany, the immigration of 500 000 people per year with a domestic TFR of 1.4 would produce a stable 25% of the population being born abroad, but with a growing and unspecified proportion of immigrant origin (Feichtinger & Steinmann 1992). In the United Kingdom, no official projection has been made since 1979 (Immigrant Statistics Unit 1979). Media speculation about a non-white majority in the United Kingdom within 100 years, apparently emanating from political sources in London, has received no academic or official endorsement, contrary to some reports. These comments seem to have been based on nothing more than a linear extrapolation of the current growth rates of the white and ethnic minority populations. New official projections, however, are being considered by the Office for National Statistics (ONS) at the time of writing (Haskey 2000).

3. PROJECTIONS OF POPULATION AGEING, IMMIGRATION AND FERTILITY

To explore the effects of demographic change on population ageing, two approaches are possible. The first is to follow the example of the UN Population Division (UNPD) in setting 'targets' for constant population, workforce and PSR, and computing the level of net migration required to meet those targets in specified years. The approach of the UNPD was to consider only the effects of migration on the demographic problems posed by population ageing or decline. Other demographic variables, as well as the benefits or costs of migration itself, were ignored. However unintentionally, the report has given to many journalists and public figures the mistaken impression that population ageing can in some sense be 'solved'.

The alternative approach is to assess the various ways in which developed societies might adjust to these changes in the structure of their populations with minimal disruption. This approach accepts that previously high levels of PSR were a historical contingency unlikely to be repeated, and that some degree of population ageing is unavoidable. To begin with, a 'reasonable' range of assumptions for future fertility, mortality and migration are projected to see what effects the full range of demographic variables might have on the age structure and its statistical indicators. Non-demographic adjustments are considered in a later section.

To explore these demographic prospects with respect to the United Kingdom, a number of projections have been made by the UK GAD over the unusually long range of 100 years, up to 2001 (Shaw 2001; Coleman 2000). These have repeated the UN 'targets' exercise, using more realistic assumptions. Further projections, described in the next section, were then made on the basis of a range of future birth and death rates, as well as migration assumptions. The GAD projections differ from those made by the United Nations and are almost certainly more reliable,

Table 3. Annual net migration 'required' to achieve given population, workforce and potential support ratio targets, at specified years in the United Kingdom, 1998–2100 (thousands).
(Source: unpublished tables from the UK Government Actuary's Department.)

	1998	2000	2010	2020	2025	2030	2040	2050	2060	2070	2080	2100
potential support ratio (PSR)												
PSR 3.0	175	99	95	95	932	629	−66	221	671	1232	−653	−32
PSR 3.5	175	99	95	939	1346	661	−74	679	2013	1206	−1260	1536
PSR 4.2 (1998)	175	99	1195	1063	1523	833	578	2651	2304	1331	974	5854
workforce absolute size aged 15–64 as in 1998	−115	−121	134	222	329	173	−11	172	226	120	38	170
population absolute size 1998 population	−75	−60	−27	14	67	134	170	162	120	107	116	123

Table 4. Population size implied by maintenance of population and workforce targets, in the United Kingdom, 1998–2100 (millions).
(Source: unpublished tables from the UK Government Actuary's Department.)

target	1998	2000	2010	2020	2025	2030	2050	2060	2080	2100
potential support ratio (PSR)										
PSR 3.0	59.2	59.8	61.6	63.5	64.2	69.1	77.0	78.0	100.6	90.8
PSR 3.5	59.3	59.8	61.6	65.0	70.5	78.8	90.0	97.3	142.6	143.9
PSR 4.2 (1998)	59.3	59.8	63.4	76.6	84.4	94.7	118.9	152.6	213.2	303.4
workforce absolute size aged 15–64 as in 1998	59.3	59.2	58.6	60.1	61.5	63.3	63.1	63.1	64.7	63.2

primarily because the United Nations seriously underestimated actual net immigration and consequently the initial population. For details, see Coleman (2000).

According to the UN model, to preserve the size of the total UK population at its current level, no further migration is 'required' until 2020, as the population continues to grow through natural increase. To preserve the size of the population of nominal working age (people aged 15–64) up to 2010 also 'requires' no migration. After that time, net immigration peaking at 380 000 per year is 'required' between 2025 and 2030 (mean 114 000 per year). This inflow adds six million to the population. The UN scenario to preserve today's PSR requires net immigration peaking at 1.8 million per year between 2025 and 2030 (mean 1.1 million per year). That figure more than doubles the population to 136 million, of whom 59% are post-1995 immigrants or their descendants, assuming equal birth rates (table 2). The UN Population Division determined these annual 'requirements' by averaging the total required over time periods to achieve given positions by 2050.

The GAD projections throw a sharper light on the demographic consequences of meeting the UN's targets through migration. GAD's more detailed work shows that the 'goals' of a constant population, workforce or support ratio are in fact very difficult or impossible to achieve. If the migration 'requirement' is calculated on a year-to-year basis, then the annual migration inflow has to become very volatile (table 3). This is because the inflows 'required' are very much at the mercy of the population age structure, which is primarily determined by the size of successive birth cohorts in all previous years. Past fluctuations in fertility thereby determine annual 'requirements' for immigrants (see Shaw 2001). The difficult stop–go immigration policy required to achieve this end in practice was first shown more than a decade ago (Blanchet 1989), and those conclusions have stood the test of time. For example, to maintain a constant PSR, the necessary annual net inflow reaches 1.5 million by 2025, falls to nearly 0.5 million, then rises to more than five million per year at the end of the century. To maintain a constant workforce size requires annual net immigration peaking at 330 000 around 2025, and a net outflow of 11 000 emigrants 15 years later. It would be impossible to control immigration in such a fine-tuned manner. These figures take no account of economic trends and workforce participation, which determine the real labour demand and the real support ratio, or the fact that most immigration is of dependants, not of workers. Extension of the projection to 2100 shows that the net immigration required to preserve the support ratio increases unevenly to reach nearly six million per year in 2100. The population sizes implied by implementation of these 'requirements' are also rather arresting, reaching 303 million by 2100 (table 4).

4. VARIANT DEMOGRAPHIC SCENARIOS FOR THE UK

The second approach to explore the effects of demographic change is to see what effect 'reasonable' variant assumptions of fertility, mortality and migration together might have on population size and age structure. These variant projections are assessed by comparison with

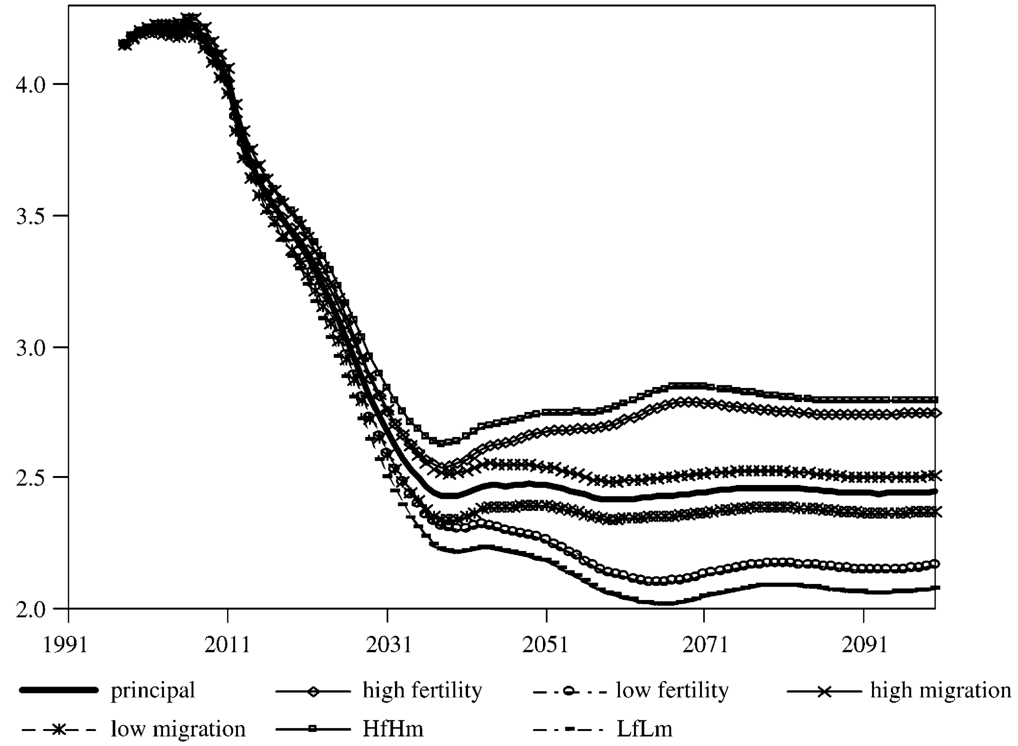

Figure 2. Trend of potential support ratio under various assumptions, UK 1998–2100. (Source: modified from fig. 7, Shaw (2001) by kind permission of the GAD.)

GAD's principal projection (Government Actuary 2000)—its 'best guess' as to future developments. Details are in figure 2 and published elsewhere (Shaw 2001; Coleman 2000). Outcomes in terms of various demographic indicators are shown in table 7 (Appendix A) for 2050 and in table 8 (Appendix B) for 2100. The effects on the PSR are summarized in figure 2. Short of the impossibly high levels of immigration 'required' to maintain the PSR, no reasonable assumptions of future demographic change make a radical difference to the PSR or any of the other indicators by 2050 (table 5). The range of the PSR, for example, is 2.25–3.12, far from the current 4.1 (the GAD principal projection gives 2.4). A selected range of outcomes is shown in figure 3. The 'best buy' gives a PSR of 3.12, but this is derived from an impossible 'no change' scenario, in which death rates remain unchanged from their present level. Excluding that, the effective range of PSR is 2.25–2.75.

It is possible to calculate the change in the demographic boundaries that define the working-age and pensioner populations that would be required to conserve the existing PSR (that is, increasing the notional size of the working-age population and diminishing the size of the dependent-aged population, by moving upwards the notional age of retirement from the present 65). In these scenarios, the notional retirement age required to conserve the existing PSR by 2050 varies from 70 to 74. A considerable degree of population ageing and decline of PSRs are thus inevitable. It is impossible for modern vital rates to preserve the age structure created by former vital rates that are now irrevocably ended. Whereas the number of nominally active people will remain almost constant from 2000 to 2061, the number of pensioners will increase rapidly after 2020. Their number then declines after 2040. A new stable population structure begins to emerge (Government Actuary 1999, fig. 4.2) as the 'baby boom' queue at last moves on from the benefit offices to the Pearly Gates.

The 'preferred' route into the future can be evaluated by considering a trade-off between maximizing the PSR and minimizing the growth of population size. It is assumed that higher PSRs are preferred and that further increase in the population is undesirable (see Coleman (2000) for further discussion of the latter). Change in PSR is intimately associated with the notional retirement age required to preserve the PSR. A return to replacement fertility with mortality and migration, as in the GAD principal projection, yields the highest PSR of all (2.75), with the population growing to 72 million by 2050. A notional working-age limit of 70.6 years would then be required to keep the PSR at 4.2. The same fertility with zero net migration, however, produces a PSR of 2.53, but with 8.7 million fewer people.

The effects of changes in fertility, immigration or survival on the PSR, holding the other two variables constant, are presented in simple tabular form. The most efficient process may be considered to be that which yields the biggest increase in PSR for the smallest percentage, or absolute increase in population size (table 6, figure 3).

Net immigration of 185 000 compared with zero migration increases the population by 14.5 million and increases the PSR by 0.36, or 0.025 per million population. Replacement fertility (with a constant 95 000 net immigration) increases the population by 10 million and PSR by 0.37. This represents a 'rate of improvement' in PSR through increased fertility of 0.037 per million increase in population, *ca.* 50% more efficient than the migration route (0.025). However, any increase in fertility brings an increase in child support costs. Even replacement TFR, of course, cannot restore a PSR of 4.1. That

Table 5. Comparison of scenarios at 2050 by order of potential support ratio.
(Except where specified, all scenarios use the same assumptions as the GAD principal projection: TFR rising to 1.8, constant migration of 95 000 per year, expectation of life rising to 79.7 and 83.9 years for males and females, respectively, by 2060. The 'working-age limit' is the corresponding formal retirement age 'required' to preserve the current potential support ratio of 4.1. e_0 is expectation of life at birth, both sexes. Source: unpublished calculations by UK Government Actuary's Department.)

projection	values in 2050 total population	median age	per cent aged 65+	support ratio	working-age limit
(actual 1998)	59.2	36.9	15.7	4.15	62.5
constant 1998 vital rates	64.2	42.7	20.4	3.12	68.3
TFR = 2.07	71.8	40.4	21.7	2.75	70.6
TFR = 2.07, high e_0	72.6	40.9	22.4	2.64	71.5
185 000 constant migration	70.6	43.4	23.2	2.61	71.1
TFR = 2.07, zero migration	63.1	41.6	23.2	2.53	72.1
GAD 1998 principal projection	64.2	44.1	24.2	2.47	72.0
TFR = 2.07, high e_0, zero migration	63.9	42.2	24.0	2.42	73.0
TFR = 1.7	61.7	45.5	25.2	2.38	72.6
high e_0	65.0	44.6	25.1	2.37	72.8
zero migration	56.1	45.8	26.0	2.25	73.6

would take a TFR of about 3 (see Shaw 2001, fig. 8b). Replacement TFR with constant zero migration generates hardly any population growth up to 2100. PSR is just over 2.5 and the disadvantages of the high migration streams in other projections are permanently avoided. Finally, increased survival sharply reduces the PSR, with a small increase in population size. The effect is to worsen PSR by 0.119 for every one million increase in population. These trade-offs are summarized in table 6.

As expected from demographic theory, fertility emerges as the most efficient factor that affects the PSR. This is particularly marked in the comparison based on the effect of a given percentage increase in the value of each independent variable. How impressive this is depends on the degree to which it is feasible to envisage changes in each variable. From 1964 to 2000, the UK TFR has varied from 2.9 to 1.7, the higher figure being 71% greater than the lower. Since 1980, it has varied between 1.7 and 1.84. Net immigration has varied from −87 000 in the 1960s, to +181 000 in the latest year (1999). During the 1980s and 1990s, the net inflow has only exceeded 100 000 in the last few exceptional years. This might become the 'norm' under current government policy. A recent Home Office publication, in parallel with ministerial announcements in 2000, indicates that net immigration of non-EU nationals alone will rise to just under 180 000 by 2005, with an implied asymptote of just under 200 000 (Glover *et al.* 2001, p. 12). This is much higher than the official Government Actuary's assumption of a fall to a constant 95 000 from all sources after 2002 (Office for National Statistics 2000, p. xi); an assumption clearly overdue for upward revision.

So far, past levels of migration, even on a scale sufficient to be controversial, have had modest effects on population structure but more impressive effects on total population. For example, in the United Kingdom, net immigration has generated almost all of the three million population growth since the mid-1970s (Coleman 1995*b*; Courbage & Compton 2002). Most age-structure effects, however, have been trivial (Murphy 1996*a*). This is also true even in those countries, such as the United States and Canada, which have traditionally enjoyed much higher rates of net immigration than the United Kingdom or most other European countries. Canada is the most extreme example. Their official policy encourages immigration in order to increase population growth by 1% per year. During the period 1951–1991, *ca.* 35% of the Canadian population were first- or second-generation immigrants, and *ca.* 50% if the third generation is included (Beaujot & Matthews 2000, p. 6). Although immigration has greatly increased the total population of Canada, its cumulative effect from 1951 to 1981 reduced the average age of the 1981 population by only half a year. For the future, official population projections made in 1990 propose a median age of 44.7 years in 2036 with 'high' immigration, compared with 46.9 years with zero immigration (Beaujot 1996, p. 4.1). Even the continuation of current high immigration flows into the United States and Canada cannot save them from considerable population ageing. For example, the 880 000 annual net immigration assumed in the US official projections of 1993 will not prevent the US PSR for the elderly falling from 4.93 in 1990 to 2.75 in 2050 (US Bureau of the Census 1993, table E). This PSR is little better than the 2.5 expected for the United Kingdom and obtained with ethnic minority growth that is sufficient to comprise half the total population by that date.

5. POSSIBLE NON-DEMOGRAPHIC RESPONSES TO POPULATION AGEING

We have already seen that immigration can only sustain the PSR at the cost of unsustainable levels of population growth, and that although a return to higher fertility would undoubtedly help the position, it cannot restore it. As there is no 'solution' to lower PSRs, the question arises whether the process can at least be moderated in other ways. In financial and actuarial circles, attention tends to be focused in fairly optimistic terms on fiscal, economic and workforce adjustments (Institute of Actuaries 2001; IIASA 2002). What matters is whether the economy can manage the changed pattern of consumption and investment, and still deliver acceptable economic growth. Most opinion suggests that it can, if birth rates remain reasonably favourable (see,

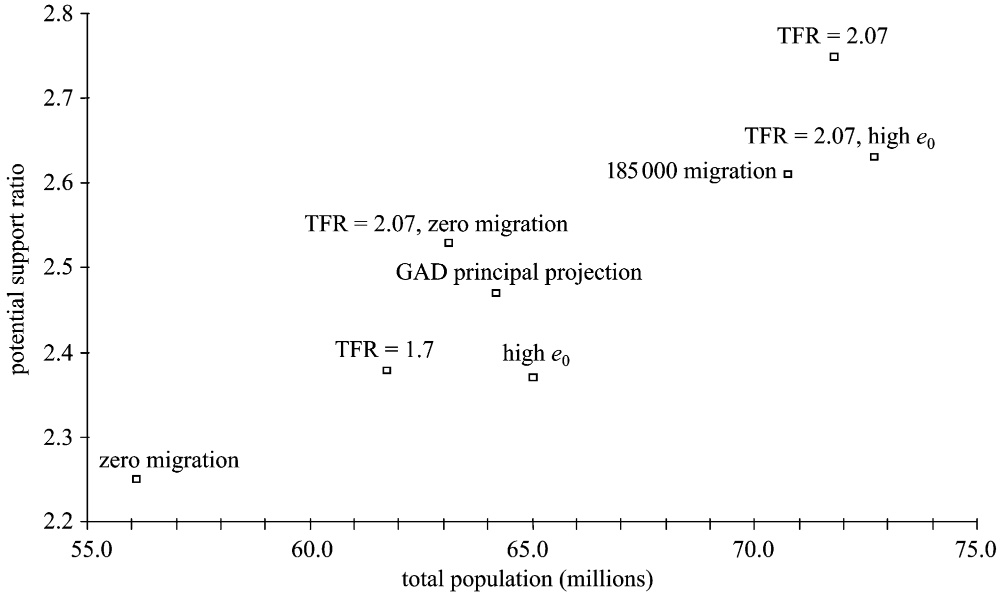

Figure 3. Population size and potential support ratio, in the United Kingdom in 2050, according to various projections.

Table 6. Relative effects on potential support ratio of changes in fertility, immigration and expectation of life at birth.

	fertility	immigration	expectation of life
absolute change in potential support ratio per million increase in population	0.037	0.025	−0.119
per cent change in potential support ratio per million increase in population	1.545	1.102	−4.689
per cent change in potential support ratio from 10% increase in each variable	7.075	0.597	−2.424

for example, Weil 1997; Mirrlees 1997; Gillion 1999). This is not the appropriate place to discuss these options in detail (see World Bank 1994; Daykin & Lewis 1999). Measures that are at present being pursued by the UK government are reviewed elsewhere (Dunnell 2001). But in brief, the favoured approach is a multiple response, divided below into three broad categories.

(a) *Improving the real, as opposed to potential, support ratio*

The actual UK workforce is only *ca.* 78% of the working-age population, because of early retirement, tertiary education, and so on. Hence, the real support ratio (RSR) of taxpayers to pension recipients is already much lower than the abstraction of the PSR. In the United Kingdom today, it is about 3.2, not 4.1, and the RSR of actual workers to all non-workers over the age of 15 today is just 1.67, a ratio evidently capable of supporting national life. There is much scope for increasing it through the following measures.

(i) RSR could be increased by encouraging higher workforce participation (through retraining of the unemployed), discouraging early retirement, reducing obstacles to internal labour mobility (Fuchs & Schmidt 2000), and above all making it easier for women to combine work with childcare through various measures that in Europe are best developed in the Scandinavian countries. An increase of workforce participation rates to Danish levels would increase the EU workforce by 30 million. In the United Kingdom, a return to the male workforce participation rates of 1971, and reasonable assumptions about the extension of female participation up to age 65 when pensionable ages are unified in 2010–2020, increases the active population to 84% of the age group.

(ii) RSR could also be increased by increasing the average age of retirement—a step made easier by longer active life. This would involve moving the pension entitlement age upwards and encouraging longer workforce participation by removing tax disincentives for working pensioners and removing employment barriers imposed solely on the grounds of age. Such steps are already in train in the United States, Italy and Japan. Table 6 shows the level of retirement age needed to compensate completely for changes in PSR in the United Kingdom (essentially by changing the definition of support ratio). Most scenarios envisaged a universal retirement age rising to about 72. Complete compensation is not needed, of course, and furthermore we are not starting from a retirement age of 65. The calculations summarized in table 6 assume a current age of 62. In reality, actual retirement age is about 58. If maintaining the PSR involves a longer nominal working life of $(72 - 65 = 7)$ years, then maintaining the RSR means a movement of normal retirement from 58 to 65 $(58 + 7)$.

(b) *Moderating the financial burden*

The financial burden of an ageing population can be ameliorated by the following measures,

(i) Later retirement and resistance to further increases in the value of state pension entitlement; for example, linking state pensions to prices not wages. The United Kingdom has already done this.

(ii) Encouragment of alternative sources of old-age support through 'second and third pillar' occupational- and private-funded pension schemes, which might have the additional advantage of improving the savings rate for investment (World Bank 1994; Daykin & Lewis 1999). More than 70% of the UK population is already covered by occupational or private schemes, in marked contrast to the continental countries (European Federation for Retirement Provision 1999; Stein 1997). However, funded pensions cannot escape all adverse demographic effects, because their value still depends on the output of the economy, for which the size of the workforce is important (Chand & Jaeger 1996; Johnson 1997).

(iii) Respond to a stationary or declining workforce by increasing capital investment to improve worker productivity. This is a desirable step in its own right, to improve Europe's poor international competitiveness, and one that would naturally follow from the pressure of higher wages that arises from any labour shortage. Several calculations have indicated that the productivity growth *per caput* that is required to cover all increased old-age dependency would amount to *ca*. 0.5% per year by 2020, that is, resulting in 2.5% growth compared with a normal annual growth of up to 3% per year.

None of these methods by itself can offer a complete solution; none is available. For example, by 2025, additional productivity improvements for the European Union would have to be *ca*. 0.8% per year if they were the sole means to meet the need for extra resources arising from population ageing; average age at retirement would have to rise from the present EU average of 60 to 66 (European Commission 1996, pp. 36–39). Many countries have already begun to implement several of these measures in order to minimize problems, and in the majority of European countries a multiple response seems to make them manageable. However, increased workforce participation is a 'one-off' response, the effects of which would not last beyond about 2025. Furthermore, the extreme low-fertility countries, especially Italy, face an apparently unsustainable burden in the long term unless their birth rate increases considerably.

6. FERTILITY PROSPECTS

The level of the birth rate has a potent effect on the level of population ageing and support ratios that populations must live with in the future. A TFR of more than about 2 is not to be expected, and even that level would not restore support ratios to previous levels or, in countries with previously lower fertility, avert a temporary period of population decline (Lutz 2000). But relatively high fertility (e.g. 1.7 or over) would greatly assist the management of ageing by the non-demographic measures noted above. Demographic opinion is divided over whether very low fertility is here to stay (Lesthaeghe 2000), whether it will recuperate from current postponement, or whether it will respond to welfare measures ('pronatalist' in intention or not). The birth rate in all countries is expected to increase to some extent, as part of the recuperation from delayed fertility. Analysis of recuperation of delayed births indicates a varied pattern of recovery to between 1.75 and 1.95 children among women now aged 30 in France, Belgium and the Netherlands, less elsewhere (Lesthaeghe 2001). Few expect a return to replacement fertility among women born in the 1960s and 1970s (Kohler & Ortega 2001; Frejka & Calot 2001). The relative buoyancy of birth rates in northwestern Europe seems to be, in part, a response to family-friendly policies. But for effective family support, underlying attitudes that are unfavourable to gender equity in the family and in society as a whole will have to change in low-fertility societies, a less predictable process (McDonald 2000).

7. OTHER MIGRATION ISSUES

Europe has been receiving variable but large net immigration flows, both regular and illegal, for many years now (see OECD 2001): the concept of 'Fortress Europe' seems far from reality. Labour migration is facilitated by the free movement of labour in the EU population of 380 million and by work permit systems for recruitment abroad. These flows are declining in some countries and increasing in others. Much of the regular labour migration is of highly skilled professional or business migration, especially intercompany transfers, which are generally welcomed as economically beneficial. Exceptional demand in some sectors, notably IT, might justify exceptional new measures according to the UK and German governments, although the projected demand for IT workers in the United Kingdom has already been cut back. In some unskilled sectors, the demand for illegal labour is strong, exploited at low wages and with low levels of job protection in marginal areas of the economy.

Since the 1970s, the flow of immigrants to most European countries has not been driven primarily by regular labour demand. Instead, they comprise mostly spouses, dependants, students, asylum seekers and others. Not surprisingly, unemployment among foreign populations as a whole is up to 40% compared with 9% generally in the Euro-zone populations, while workforce participation rates of immigrants, especially females, are often low. Although the immigration of dependants and the arrival of asylum seekers and illegal entrants will continue, they do not seem to be very relevant to Europe's foreseeable economic needs, or helpful to the coherence of its society. More broadly, reliance on the apparently easy option of importing labour from overseas, the employment of illegal immigrants for low wages and the consequent diminution of training in employment, might not help Europe's central economic problem, that of low productivity. Productivity levels in Europe are still substantially below those of their major competitors. There is little merit in perpetuating low-wage, low-output domestic enterprises that can only survive with marginal labour, and the goods or services of which (such as data processing) can be imported instead. That impedes the modernization and capitalization of the domestic economy, as well as depriving foreign countries of their markets.

8. ENVIRONMENTAL ASPECTS OF POPULATION

The debate on future population growth or decline, and population ageing, has been conducted almost entirely in terms of its effects on economic growth and material living standards, and the supposed political imperative to protect living standards from these and other threats. It should be noted that a parallel debate has proceeded for decades on population, in the shadow of the first and in isolation from it, with different priorities and different views as to what constitutes 'acceptable' economic growth. Here, protagonists are concerned with the sustainability of the environment, not of pensions systems, believing that levels of consumption are already too high in the developed world, and that the global resource base and environment are being degraded by the current economic system (Goudie 1994), not least because of the effects on the sustainable level of world population through global warming. On this view, low fertility and population decline in the developed world are to be welcomed (Willey 2000), irrespective, it would seem, of their effects on population ageing. Thereby, the numbers of high consumers in the world ecosystem would be reduced (Myers 1998). Immigration is unwelcome because it transfers population from low-consumption to high-consumption societies. On a more parochial level, population growth is opposed, at least in the United Kingdom, because of the pressure it exerts, through leisure and housing demand, on the rural environment (Barker 2000). UK countryside pressure groups, however, seldom make the connection between population growth and immigration.

Environmental change and the exhaustion of ecosystems, through global warming or population growth exceeding water supplies in arid areas (Parry 1995), might provoke forced migration to add to existing flows (Myers 1995). The large populations, notably in North Africa, the Middle East and Bangladesh, now living in increasingly marginal environments that are threatened by climate change, require us to take this prospect seriously. However, in the author's view the term 'environmental refugee' is somewhat regrettable (the term 'refugee' is more usefully reserved for those fleeing specific political persecution). Forced migration for subsistence is hardly new, of course: witness the numerous migration episodes provoked by famine and, more interestingly, the apparently chronic imbalance between population and subsistence base of many nomadic populations in Eurasia over two millennia. Further population growth and deterioration of environment, whether through local or global processes, might require us radically to re-think migration assumptions. So far, however, movements of this kind have normally displaced populations to neighbouring poor countries rather than to the West. Although it is impossible to develop these points further here, their mention might serve as a reminder that this paper only deals with a limited range of the long-term and large-scale issues facing human population size in the 21st century.

9. CONCLUSIONS

There are no feasible migration solutions to the age-structure change and its effects on social security. It is not caused by a deficit in migration, but by low fertility and increased expectation of life. A return to previously high levels of fertility is clearly not an option either. In the long term, a return to approximately replacement level fertility would eventually moderate population ageing, and even then not without some intervening demographic decline in countries that have experienced sub-replacement fertility for decades. Nothing will ever bring back the age structure of previous centuries. Whatever the demographic response, changes in the balance between consumption and production are inevitable (Weil 1997). These problems seem to be manageable, though not finally soluble, in most European countries (Ermisch 1990) as long as permanent very low fertility can be avoided. Europe has already weathered a trebling of the old age population, from 5 to 15% since 1900. In populations with reasonably high fertility (e.g. between 1.7 and 2), various non-demographic reforms to pensions systems, the labour market, retirement age and economic productivity offer plausible routes for the long-term management of an older population without serious negative economic consequences. Many of these steps are already being introduced or actively considered by the governments of developed countries. European countries seem nearly certain to face the end of population growth, and the onset of mild decline, in the 21st century. These trends might have some beneficial as well as harmful effects; their economic, social and environmental consequences need more intensive research.

Europe has already experienced one episode of mass migration, which has still not ended. It has not prevented population ageing and, although labour migration is generally judged to be economically beneficial, overall it is less clear if the migration process as a whole has had demonstrably favourable consequences either for the immigrants or for the host populations. Opinions still differ widely about the appropriate measures to encourage the integration and possibly the assimilation of the growing populations of immigrants, foreigners and their children (Coleman 1992). Some such groups are now very successful, others remain marginalized, subject to high levels of discrimination, unemployment, poverty and, in the younger generation, disproportionate under-achievement and involvement in crime (Smith 1994) and disorder. Resolution of these problems might be an appropriate goal before any further resumption of mass immigration is contemplated.

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APPENDIX A

Table 7. UK variant projections based on 1998 GAD principal projection to 2050.
(Source: unpublished calculations by UK Government Actuary's Department, 2000.)

	projection											
values 2050	1 zero migration	2 185 000 migration	3 TFR 2.07	4 TFR 2.00	5 TFR 1.70	5b TFR 2.0 zero migration	5c TFR 2.07 zero migration	6 high e_0	7 TFR 2.07 high e_0	8 TFR 2.0 high e_0	11 constant 1998	GAD principal projection
variable												
population	56 108	70 630	71 796	69 527	61 733	60 976	63 059	65 028	72 649	70 378	64 187	64 181
median age	45.8	43.4	40.4	41.3	45.5	42.7	41.6	44.6	40.9	41.8	42.7	44.1
population aged 65+	14 608	16 413	15 556	15 556	15 556	14 608	14 608	16 296	16 296	16 296	13 121	15 556
percentage 15–64	58.7	60.7	59.7	59.7	60.0	58.6	58.7	59.3	59.1	59.2	63.7	59.9
percentage 65+	26.0	23.2	21.7	22.4	25.2	24	23.2	25.1	22.4	23.2	20.4	24.2
support ratio	2.25	2.61	2.75	2.67	2.38	2.45	2.53	2.37	2.64	2.56	3.12	2.47
population change	−240	81	147	91	−133	−103	−54	−11	209	144	−53	0.64
population growth (%)	−0.42	0.12	0.20	0.13	−0.21	−0.17	−0.09	−0.02	0.29	0.21	−0.08	−0.10
net migration	0	185	95	95	95	0	0	95	95	95	185	95
TFR	1.8	1.8	2.1	2.0	1.7	2.0	2.1	1.8	2.1	2.0	1.7	1.8
e_0 male	79.7	79.7	79.7	79.7	79.7	79.7	79.7	81.1	81.1	81.1	74.9	79.7
e_0 female	83.9	83.9	83.9	83.9	83.9	83.9	83.9	85.2	85.2	85.2	79.7	83.9
upper limit of working age needed to obtain given potential support ratios												
support ratio	upper limit of working age											
4.09 (1995)	73.6	71.1	70.6	71.1	72.6	72.5	72.1	72.8	71.5	71.9	68.3	72.0
3.5	71.3	69.1	68.4	69.0	70.4	70.3	69.9	70.6	69.3	69.7	66.4	69.9
3.0	69.2	67.0	66.1	66.7	68.3	68.1	67.6	68.5	67.0	67.4	64.5	67.8
difference at 2050 between GAD principal projection and successive projections												
population total	−8073	6449	7615	5346	−2448	−3205	−1122	847	8468	6197	6	0
population total (%)	−12.58	10.05	11.86	8.33	−3.81	−4.99	−1.75	1.32	13.19	9.66	0.01	0.00
percentage 65+	1.80	−1.00	−2.50	−1.80	1.00	−0.20	−1.00	0.90	−1.80	−1.00	−3.80	0.00
support ratio	−0.22	0.14	0.28	0.20	−0.09	−0.02	0.06	−0.10	0.17	0.09	0.65	0.00

APPENDIX B

Table 8. Variant projections based on 1998 GAD principal projection: UK population 2100.
(Source: unpublished calculations by UK Government Actuary's Department, 22 and 31 August 2000.)

	projection											
values 2100	1 zero migration	2 185 000 migration	3 TFR 2..07	4 TFR 2.00	5 TFR 1.70	5b TFR 2.0 zero migration	5c TFR 2.07 zero migration	6 high e_0	7 TFR 2.07 high e_0	8 TFR 2.0 high e_0	11 constant 1998	GAD principal projection
variable												
population	44 257	72 625	81 808	75 130	53 624	57 204	62 994	64 519	86 956	80 080	61 004	60 052
median age	45.7	43.5	40.1	41.2	45.4	42.3	41.1	46.8	42.6	43.7	42.6	44
population aged 65+	11 702	17 173	17 219	16 461	13 815	13 354	14 055	18 704	21 784	20 873	12 671	14 660
percentage 15–64	58.2	60.3	60.2	60.2	59.4	59.1	59.3	56.2	57.3	57.1	63.3	59.7
percentage 65+	26.4	23.6	21	21.9	25.8	23.3	22.3	29	26.1	26.1	20.8	24.4
support ratio	2.2	2.55	2.86	2.75	2.31	2.53	2.66	1.94	2.29	2.19	3.05	2.45
population change	−212	39	219	124	−144	−60	16	4	327	223	−54	−71
population growth (%)	−0.47	0.05	0.27	0.17	−0.26	−0.1	0.03	0.01	0.38	0.28	−0.09	−0.12
net migration	0	185	95	95	95	0	0	95	95	95	185	95
TFR	1.800	1.800	2.070	2.000	1.700	2.000	2.075	1.800	2.070	2.000	1.700	1.800
e_0 male	80.1	80.1	80.1	80.1	80.1	80.1	80.1	86.5	86.5	86.5	74.9	80.1
e_0 female	84.2	84.2	84.2	84.2	84.2	84.2	84.2	90.4	90.4	90.4	79.7	84.2
upper limit of working age needed to obtain given potential support ratios at 2050												
support ratio	upper limit of working age											
4.1 (1995)	73.6	71.1	70.6	71.1	72.6	72.5	72.1	72.8	71.5	71.9	68.3	72.0
3.5	71.3	69.1	68.4	69.0	70.4	70.3	69.9	70.6	69.3	69.7	66.4	69.9
3.0	69.2	67.0	66.1	66.7	68.3	68.1	67.6	68.5	67.0	67.4	64.5	67.3
difference at 2100 between GAD principal projection and successive projections												
population	−15 795	12 573	21 756	15 078	−6428	−2848	2942	4467	26 904	20 028	952	0
population total (%)	−26.30	20.94	36.23	25.11	−10.70	−4.74	4.90	7.44	44.80	33.35	1.59	0.00
percentage 65+	2.00	−0.80	−3.40	−2.50	1.40	−1.10	−2.10	4.60	1.70	1.70	−3.60	0.00
support ratio	−0.25	0.10	0.41	0.30	−0.14	0.08	0.21	−0.51	−0.16	−0.26	0.60	0.00

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